Fermilab
ES&H Section

Fermilab
Environmental Monitoring Program
(EMP)

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Environmental Monitoring Program

I. Introduction

It is the goal of the Fermilab Environmental Monitoring Program (Program) to assist Laboratory management in decision-making by providing data relevant to impacts that Fermilab operations have on the surrounding environment as part of the facility's Environmental Management System (EMS). The Laboratory Director depends on the Program to identify potential vulnerabilities, and to propose appropriate methods for understanding their underlying causes and processes. The Program outlines the types and locations of samples that are routinely taken, and the reasons that led to scheduling the collection of a sample in a location at a particular time. This program is effective only when used in conjunction with the more comprehensive EMS. The EMS includes relevant policies of the Laboratory as set forward in the Director's Policy Manual and the Fermilab ES&H Manual, and the infrastructure to allow adequate evaluation of the operations to determine the optimum use of monitoring resources. The overall EMS includes elements to identify significant aspects such as potential sources of contamination, the necessary information to identify reasonable pathways from sources to the environment and the public, and measures available to reduce the impact of facility operations on the environment.

The Program consists of two elements: effluent monitoring and environmental surveillance. Effluent monitoring documents compliance with permits, and is conducted at specific locations. Environmental surveillance is conducted at various locations in the path of potential pollutants to receptors such as plants, animals or members of the public. Environmental data is collected for reporting purposes or whenever it is necessary or useful in conducting the business of the Laboratory. The operation of the Program is primarily the responsibility of the

Environmental Protection (EP) Team in the Safety and Environmental Protection (SEP) Group, of the Environment, Safety and Health (ES&H) Section.

Line organizations are responsible for recognizing and understanding the environmental consequences of all their operations and for conducting their operations in an environmentally sound manner. Line organizations also design and implement sample scheduling and data collection appropriate to their operations. The EP team is available to provide assistance to line organizations upon request. The EP team is ultimately responsible for overall coordination of the sampling schedule and data analysis across the Laboratory.

The primary environmental monitoring planning tool is the sampling schedule. The schedule indicates the location and frequency of sampling, based on established routines, operational considerations, and historic levels of pollutants found in each location. Laboratory management is advised when modifications to this schedule are necessary. The sampling schedule is intended to be a short to medium term plan that is modified as needed by evolving circumstances. A copy of the current schedule can be found in the *Fermilab Environmental Database* (FED), which is maintained on the ES&H server.

As analytical results are received, they are recorded in the FED and/or the Oracle ES&H/EP Sample database. Thus, a comprehensive record of all environmental monitoring results is available to future planners, and for retrospective baseline studies.

II. Objectives of the Fermilab Environmental Program

The objectives of the program are to collect data of known quality to:

1. Assess the potential impacts of our activities on the environment and/or the public,
2. Verify compliance with legal requirements (e.g., permits and state standards) or other commitments (e.g., policy statements, As Low As Reasonably Achievable (ALARA) program, and National Environmental Policy Act (NEPA) commitments),
3. Characterize the environment in the vicinity of the Laboratory, including baseline studies or background data,

4. Help to identify potential problems that may arise due to flaws in design, construction, and/or the implementation of work,
5. Evaluate remedial measures that have been previously instituted, and
6. Characterize and track releases of any contaminants into the environment.

III. Air Monitoring

Fermilab processes result in minor emissions of radionuclides, primarily from vent stacks located above beam enclosure areas; and non-radioactive emissions such as particulate matter, nitrogen oxides, carbon monoxide, volatile organic material and sulfur oxides. These emissions originate from boilers or heating units that burn natural gas or other fuel.

Radionuclide monitoring

Radionuclides are considered by the U.S. Environmental Protection Agency (U.S. EPA) to be a Hazardous Air Pollutant, therefore, we have a permit under the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) program[1]. This lifetime permit requires that we prepare a report on NESHAPs pollutants each year and submit it to U.S. EPA.

Emissions from selected vent stacks are monitored directly, by continuous stack monitors[2], and indirectly, by taking representative soil samples in the vicinity of stacks. Soil samples indicate the potential for deposition of radionuclides originating from the vent stacks. Both are analyzed for tritium and gamma-emitting radionuclides. The determination of which individual stacks to be monitored is based on the potential for airborne radioactivity at the stack location. Standard procedures are used to collect and analyze both the stack samples and the soil samples.[3]

Non-radionuclide monitoring

Emissions of particulate matter and oxides of nitrogen and sulfur result from burning fossil fuels in several boilers and heating units located in several locations around the site. Fermilab holds a permit from the Illinois Environmental Protection Agency (IEPA) to operate these emission sources under the Clean Air Act. In order to comply with the permit, we must maintain documentation, based on equipment parameters and fuel consumption data, that verify that our emissions meet our permit conditions. An emissions report is submitted annually to the IEPA. Emissions from these sources are not normally monitored directly but are estimated using U. S. EPA emission factors and fuel consumption data.

The Debonding Oven

Fermilab has the ability to re-use magnets and other components rather than discarding them. In most cases, this requires that old epoxy resins be thermally removed from the metallic parts of the magnet prior to its rehabilitation. This process occurs in the debonding oven, located north of Industrial Building #2. The debonding oven emits radionuclides and volatile organic materials (VOMs) from the stack. Occasionally, stack gasses are sampled, however the normal monitoring strategy is to estimate emissions based on previously measured emission factors[4], equipment parameters and hours of operation. Direct sampling is used to confirm and calibrate the estimation process.

Ambient Air Monitoring

Ambient air is not monitored at Fermilab, because our emissions do not detectably modify the air quality. There are sources of regional air quality data available to us if needed. Argonne National Laboratory and O'Hare International Airport maintain National Oceanic and Atmospheric Administration (NOAA)-sanctioned ambient air quality monitoring stations. We have used data from both locations in the past as needed.

An on-site meteorological station is maintained near the New Muon Laboratory, north of Wilson Street, in the northern portion of the site. Air temperature, wind velocity and direction, relative humidity, precipitation, and solar radiation are logged at this site. All instruments are regularly calibrated[5]. Wind velocity data from this station is used to model air dispersion, using the U.S. EPA's CAP88-PC2 computer program. Results of this simulation are required for the annual NESHAPs report to the USEPA and IEPA. Precipitation data from this station is used to ensure compliance with post-storm, erosion control inspection requirements at construction sites (see Stormwater Monitoring, below).

IV. Surface Water Monitoring

We sample surface water to:

g. assess the potential for direct or indirect impacts on the environment and the public,
h. identify actual impacts on the environment, e.g., the food chain,
i. confirm compliance with a number of permits and regulations (including Derived Concentration Guides provided by DOE)[6]).

Fermilab processes discharge water to "Waters of the State[7]" at three points, called outfalls. They are located at: (1) the discharge of the transfer ditch from Casey's Pond to Kress Creek, (2) at the point where water from A.E. Sea flows into the Sea of Evanescence (and eventually into Ferry Creek), and (3) at the point where Indian Creek flows begin at the downstream coffer dam from the Swan Lake cooling waters. We have a permit under the state-run federal National Pollutant Discharge Elimination System (NPDES) and are required to monitor at each outfall and report the results monthly.

Fermilab construction projects discharge water at different points depending on the type of construction and on the location of the project to internal process waters and external "Waters of the State." We obtain permit coverage under the state-run NPDES for construction projects and are required to monitor and report the results, depending on the project.

We sample surface water from ditches that conduct cooling water from experimental areas. We also sample sanitary wastewater at the point where it leaves the site[8]. The surface water monitoring program includes sediment monitoring at selected locations.

Outfall Monitoring

Our permit requires monitoring of temperature, pH, and an estimate of flow at all permitted outfalls. Total Residual Chlorine is also monitored at Indian and Kress Creeks and total dissolved solids, total sulfate, and total chloride are monitored at Indian Creek. We also monitor temperatures "upstream" and "downstream" of our discharge at Kress Creek[9]. The permit prescribes procedures for these analyses[10]. These analyses are performed once per month. Because the surface water is recirculated for cooling as much as possible, water does not continuously leave the site at the Kress and Ferry Creek outfalls. Sampling occurs only when water is observed flowing at the outfalls. We survey these locations periodically and conduct the sampling and analysis as early in the month as possible.

In addition to the NPDES parameters, we sample for radionuclides, according to the annual sample schedule, each month at all three outfalls, when water is flowing off site from these locations. No additional chemical analysis is scheduled unless a specific spill or other release calls for it.

Monitoring of surface water discharges associated with construction activities is performed on an "as required" basis.

Sump Monitoring

Numerous sumps located throughout the site collect and store water that drains from building and other structure footers, and from "bathtubs"[11] in experimental areas. Water collected in the sumps, especially those in experimental areas, may be contaminated with radionuclides. The operational division or section has direct responsibility for these areas to ensure that sump contents are appropriately monitored and analyzed. Normally, these sumps are analyzed for radionuclide concentrations only, unless a chemical spill has been detected. Analytical results from these samples are valuable in detecting changes in operational conditions that may indicate an event that needs attention. While these samples are not considered to be strictly "environmental" monitoring, their results are useful to fully characterize sources, and as input to the sampling schedule. The EP team coordinates with other organizations that collect samples of this kind to ensure that the most useful information possible is obtained.

Ditch Monitoring

Stormwater is collected from most of the site and stored as cooling water for site operations. A series of ditches circulates cooling water between operational locations and lakes and ponds where evaporative cooling occurs. Sumps (see above) are discharged into these ditches, creating the potential for radioactive contamination of cooling water. We monitor radionuclide concentrations of water in the ditches to assess the cumulative impact of sump discharges. Specific downstream sampling points are chosen as close as possible to the effluent, at a point where a representative sample is insured. Additional samples are sometimes taken further downstream of releases to track migration of contaminants. These samples, in combination with outfall sampling provide a comprehensive picture of detectable releases.

Sanitary Discharge Monitoring

Sanitary waste effluent is discharged either to the Warrenville system to the east, or the Batavia system to the west. The sanitary sewage also contains some process wastewater. Process wastes can be discharged to the sanitary sewerage system only if they comply with strict guidelines listed in the Fermilab ES&H Manual (FESHM) Chapter 8025. We monitor our sewage as it leaves the site to document our compliance with Warrenville and Batavia ordinances regulating allowable sanitary discharges.

We have two automated self-contained samplers that are programmed to take composite samples on a continuous basis during normal laboratory operational hours from these waste streams. The samples are analyzed monthly for heavy metals, since these are the potential contaminants of most concern to the two municipalities, as well as pH and tritium. Data from these samplers are used to confirm compliance of Fermilab's sanitary discharge with local and state regulations.

Sediment Monitoring

A part of the surface water sampling and monitoring program is collection and testing of sediment samples from selected surface water bodies for gamma-emitting radionuclides. These sampling locations are selected on the basis of effluents and the experimental activity in the vicinity, just like the ditch samples. Results from these samples can alert us to potential accumulation of contaminants in the sediments.

Pesticide Monitoring

Fermilab uses pesticides for land and water management purposes. In addition, the Laboratory leases a significant area to local farmers who raise row crops. This agricultural activity involves additional pesticide use. The farmers who lease land at Fermilab must submit a plan that details the amounts and methods of application for pesticides they intend to use. The ES&H Section reviews these plans prior to use. Pesticides used by the Fermilab Roads and Grounds crews are also subject to review prior to use. These administrative controls are designed to minimize the cumulative impact of pesticides in the environment[12].

An algaecide is used to reduce algal growth in the cooling ponds. Algae can inhibit the quality of the water for cooling, and create fouling problems in machinery if allowed to go unchecked. Roads and Grounds crews apply a copper-based algaecide as needed. We have in the past taken surface water samples to track copper levels in the water when this chemical was applied. Future sampling would be on an as needed basis.

Stormwater Monitoring

Stormwater run-off is regulated through NPDES permits to control "non-point source" contamination[13] of water bodies. At Fermilab, we have two categories of stormwater permit: those specific to construction projects[14] and a site-wide permit that regulates solid waste management units (SWMUs) associated with the Resource Conservation and Recovery Act (RCRA)[15] Facility Investigation (RFI)[16]. These programs require that the Laboratory prepare and maintain a Stormwater Pollution Prevention Plan to address the prevention of pollution by stormwater run-off at each site.

Various samples may be taken to assist in the preparation of such a plan. If new SWMUs are identified, stormwater samples may also be taken for compliance purposes. Otherwise, we do not take samples on a routine basis for this program. Sub-contractors working on permitted construction projects are required to carry out inspections on a regular schedule, and in response to significant storms, to ensure that erosion control measures remain intact and effective.

Off-site Monitoring

We do not regularly take samples from off-site locations, with the exception of upstream and downstream samples in Kress Creek (see above). We sample off-site waters as needed to track releases from the site, or to characterize water that enters the Fermilab cooling system. Fox River water is routinely used to make up water volume in the surface waters at

Fermilab[17]. This intake is sampled only when necessary to compare with levels of a particular constituent on site.

V. Ground Water Monitoring

Monitoring ground water beneath Fermilab is important chiefly to quickly identify radioactive contamination of ground water resources should radionuclides migrate downward from activated soil in the vicinity of beamlines and other experimental areas[18]. Ground water is also monitored in the vicinity of some SWMUs to detect the presence of other potential contaminants. Some samples are taken to track background characteristics of ground water in the area. When new wells are installed, we can take samples from the drill cuttings or from a continuous core at intervals to characterize the soil as well.

Source-specific Monitoring Wells

Source-specific monitoring wells are located and constructed solely for the purpose of the early detection of contaminants from a potential source so that quick and effective preventive or remedial action can be taken. The general procedure for constructing wells of this kind is to characterize the underlying geology and hydrogeology[19], and then construct monitoring wells to capture water from a specific depth[20].

Currently, there are seven such wells finished in the upper bedrock aquifer to monitor any potential radionuclide release (NS1, NS2 (2), MS1 and PE3 in the fixed target beamline area, C0 in the main ring area, and MI40 in the main injector area). There are four additional monitoring wells finished in the aquifer at an abandoned tile field near the center of the Main Ring to monitor chromates, chloride ion and select metals (part of the RFI). Six additional wells constructed at this location monitor the glacial deposits. There are eight wells in the vicinity of the Meson Hill Landfill to monitor for the presence of organic constituents and metals (also part of the RFI) within the glacial till. Four additional wells were constructed in the upper bedrock aquifer upgradient of laboratory operational areas to monitor background chemical and radiochemical concentrations.

Piezometers

Piezometers are monitoring wells installed to specific depths in the subsurface to monitor ground water level at that point. They are used to determine gradients, and are part of the process of determining the appropriate site and depth for source-specific monitoring wells. We have several piezometers that remain in place for the purpose of monitoring the ground water gradient change over time to confirm the monitoring wells continue to serve their intended purpose. In the event that ground water flow should change direction[21], the change would be detected by using data from the piezometers, and new source-specific wells would be considered.

Pre-existing Residential Wells

Old farm wells, which were installed by residents prior to the existence of the Laboratory, have been modified to serve as additional piezometers to monitor ground water levels in the upper bedrock aquifer and extend the information on flow directions beyond operational areas. The wells are not optimally useful for discovering contaminant releases, however, because of their construction. In the past, radiochemical analyses have been carried out on samples from these wells, since they were the only ground water samples available. No significant contamination was ever detected in any of the wells. As new wells have been installed to monitor specific sites for specific contaminants, the use of residential wells for sampling was eliminated.

VI. Penetrating Radiation Monitoring

Penetrating radiation (muons, gamma rays, and neutrons) is present as a result of Fermilab operations. We monitor at several points to ensure that the public is not exposed to harmful levels of radiation. There are published limits for radiation exposure[22], however, the most important principle for radiation is the ALARA criterion. This principle, as well as much of the controlling policy, etc. can be found in the Fermilab Radiological Control Manual.

Beam-related Radiation

Radiation, primarily in the form of muons, is produced during the operation of the Fermilab experimental program. We monitor radiation at the site boundary by using a Mobile Environmental Radiation Laboratory

(MERL) equipped as a mobile detector. Using the MERL, we can conduct measurements of radiation at each point along the site boundary to produce a profile of radiation. These data have proven useful for demonstrating the extremely low off-site radioactive emissions resulting from Lab operations.

Radioactive Material Storage

Radioactive materials are stored in the railhead storage area near the northern boundary of the site. Radioactivity emitted from these materials is relatively weak, however, we monitor radioactivity from this source using a large ionization chamber (called a "Hippo") that is permanently located between the source and the site boundary. The radiation measurements detected at this close range to the radioactive material are then used to extrapolate a site boundary dose.

VII. Ecological Surveillance

The purpose of sampling plant and animal tissue directly is to track the bioaccumulation of contaminants, including both radiological and non-radiological. The levels of contaminant present in the ambient environment are sufficiently low at Fermilab that we do not routinely sample in this way.

Biological surveillance was carried out on various samples of vegetation and fish from 1981 to 1989. Analyses were done for tritium, other radionuclides, heavy metals and PCBs. Levels of all contaminants were either extremely low or less than the detection limit. Tissue sampling has been discontinued since that time, because it is considered to be unnecessary and of little value, given the extremely low levels of contaminants found. In 1998, deer tissue was sampled for documentation before beginning a long-term control/maintenance program.

We currently use a computer model, DOE's technical guidance (DOE-STD-1153-2002) and companion tool, the RAD-BCG Calculator, to address radiological protection of aquatic and terrestrial biota. On an annual basis soil and sediment samples are collected throughout the site in conjunction with water samples collected from sumps, ditches, and creeks according to routine sampling schedules. All locations analyzed have consistently passed the site screens. Thus, the radiological protection of biota is considered to be adequate.

In the event a significant release and pathway were identified, that could potentially impact the environment or the public, we would re-institute such a sampling program.

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[1]NESHAPs applicable standards and regulations are published at 40 CFR 61 Subpart H.
[2] See discussion of procedures in Fermilab EP Note #9. NESHAPs standards dictate continuous stack monitoring only for emissions above a certain threshold. We have never reached this threshold, and therefore are not technically required to monitor stacks continuously. We have adopted this practice for several stacks as a "best management practice".
[3] The stack monitoring procedures are discussed in the Airborne Rad Emission MOU Program Procedure Manual (RPS). Soil sampling and analysis is described in the Environmental Protection Procedures Manual (EPPM).
[4] Factors are rates of NO_x, sulfur oxides, and particulate matter produced per unit time.
[5] See EPPM.
[6] Derived Concentration Guides are calculated limits and are discussed and tabulated in DOE Order 5400.5.
[7] Waters of the State are those waters that are legally protected by state and federal laws. Waters of the State are defined in the state regulations at 35 IAC 301.440.
[8] Fermilab discharges sanitary sewage to Batavia system to the west, and to the Warrenville system to the east.
[9] The NPDES permit requires that we monitor and record upstream and downstream temperatures, but we are not required to report to the state unless the temperature differential exceeds five degrees F.
[10] Approved procedures are located in 40 CFR 136, and the current edition of Standard Methods.
[11] Bathtubs are impermeable liners that are designed to intercept or retard water flow from areas where soil is activated, to ground water at lower elevations. This intercepted water is collected in sumps for subsequent release to surface water.
[12] Procedures are defined in the Fermilab ES&H Manual Chapter 8040.2.
[13] see 40 CFR 120-126.
[14] Any construction project that results in an impact greater than one acre must have a permit under the regulations. The permits typically require erosion control structures and practices be implemented, and documented by inspections.
[15] Resource Conservation and Recovery Act.
[16] SWMUs are areas where hazardous wastes or products have historically been stored. The RFI process identifies and investigates these potential sources of contamination.
[17] Fermilab maintains a permit with the State of Illinois to pump water under certain specified conditions.
[18] Derived Concentration Guides are published for radionuclides in ground water in DOE Order 5400.5. The state of Illinois has ground water standards, published at 35 IAC

620. Fermilab meets administrative controls with the requirements of a 1 pCi/ml lower limit of detection for ^{3}H analysis.

[19] The upper geology that underlies Fermilab is typically 50 - 70 feet of fine-grained clay, termed glacial till. The underlying bedrock aquifer is dolomitic limestone.

[20] A more extensive description can be found in the Fermilab Ground Water Protection Management Plan.

[21] Flow of ground water in the upper aquifer is generally very stable in this region, and under normal circumstances, the horizontal gradient would not be expected to change. However, production wells typically distort the gradient within an area determined by the flow rate of the well. In the event that new production wells are added, or existing well pumping rates are modified, the horizontal gradient could be substantially changed.

[22] DOE has regulations at 10 CFR 835 covering Occupational Radiation Exposure. There regulations pending to apply to Environmental Radiation Exposure, which will be published eventually at 10 CFR 834.